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DEPARTMENT OF
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OKANOGAN WASTEWATER TREATMENT PLANT RECEIVING WATER SURVEY OCTOBER 1988

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ABSTRACT

A receiving water study was conducted on October 18-19, 1988, for the Okanogan Wastewater Treatment Plant (WTP) which discharges to the Okanogan River. Thorough, rapid mixing was observed. Fecal coliform bacteria exceeded the water quality standard both above and below the WTP following a brief rain event on October 18 (0.2 inch). Water quality close to the outfall was much improved compared to 1977 in terms of total residual chlorine (TRC), specific conductance, and temperature. Recommendations include establishing a dilution zone 300 feet long, allowance for un-ionized ammonia acute toxicity close to the outfall; i.e., 30 feet or 10% of the length of the dilution zone, and establishing a permit limit for TRC of 0.7 mg/L.

PROJECT PURPOSE

The purpose of the study was to determine effects from the Okanogan Wastewater Treatment Plant (WTP) discharge on the Okanogan River at low river flow. Recent operational problems at the plant prompted a request from John Hodgson of the Central Regional Office (CRO) for a receiving water study and WTP Class II inspection by Environmental Investigations' (EILS) Surface Water Investigations and Compliance Monitoring Sections, respectively. Neither the WTP nor the receiving water had been intensively evaluated since the plant was rebuilt in 1983.

BACKGROUND

The Okanogan WTP, located in north-central Washington, serves about 2,360 people. The plant discharges into the Okanogan River downstream of the town of Okanogan at river mile 24.8 (Figure 1). The plant is regulated under NPDES (National Pollutant Discharge Elimination System) Permit WA 002236-5 which expires on June 9, 1990 (Table 1).

The WTP was substantially upgraded in 1983 from a conventional trickling filter secondary treatment system to a rotating biological contractor. Before the upgrade, receiving water impacts in the mixing zone were substantial (Kittle and Prescott, 1978). Temperature, dissolved oxygen, conductivity, and nutrients were affected 50 feet from the outfall. Total residual chlorine also exceeded current acute and chronic toxicity limits 100 feet below the outfall, while un-ionized ammonia exceeded toxicity criteria 50 feet downstream.

Operation and maintenance problems at the WTP prior to the study (Porath, 1988) as well as questions about the effects of the plant upgrade on receiving water quality prompted the study. A simultaneous Class II inspection of the plant was conducted by the EILS Compliance Monitoring Section (Reif, 1990)

The Okanogan River is fast-flowing in the area near the Okanogan WTP. The WTP outfall is located above a riffle area near RM 24.77 (Figure 1).

One of the most sensitive beneficial uses in this stretch of the river is autumn salmon spawning. An average of eight to ten native summer chinook salmon redds per year have been found near the town of Okanogan in recent years (Zook, 1989). Spawning usually occurs in October, coinciding with minimum river flow and correspondingly low dilution of waste inputs. Eggs remain in the gravel for about seven months.

In addition to the WTP discharge, CRO requested that an intermittent discharge at the Starcrisp apple packing plant upstream of the WTP (RM 25.7) be investigated. The discharge from a 10,000-gallon float tank was thought to contain potentially high levels of chlorine (Porath, 1988). Based on discussions with the plant owner, the once weekly discharge was believed to flow directly into the river. An unknown volume of non-contact cooling water was also known to discharge to the river.

Table 1. Okanogan Wastewater Treatment Plant NPDES permit effluent limits.

Permit No. WA-002236-5

EFFLUENT LIMITATIONS

After treatment, the permittee is authorized to discharge subject to meeting the following limitations for secondary treatment:

The monthly average quantity of effluent discharge shall not exceed 0.54 mgd.

Parameter	EFFLUENT LIMITATIONS Monthly Average	Weekly Average
Biochemical Oxygen Demand* (5 day)	30 mg/l; 135 lbs/day	45 mg/l; 203 lbs/day
Suspended Solids*	30 mg/l; 135 lbs/day	45 mg/l; 203 lbs/day
Fecal Coliform Bacteria	200/100 ml	400/100 ml
pH	shall not be outside the range 6.0 to 9.0	

The monthly and weekly averages for BOD_5 and Suspended Solids are based on the arithmetic mean of the samples taken. The averages for fecal coliform are based on the geometric mean of the samples taken.

*The monthly average effluent concentration limitations for BOD_5 and Suspended Solids shall not exceed 30 mg/l or 15 percent of the respective influent concentrations, whichever is more stringent. 85% removal will not apply during an Okanogan River flood event equal to, or greater than, the one in 10-year flood which is equivalent to a river level of 814 feet as measured at the USGS river gauge near Okanogan and a stream flow of 20,000 cfs.

Total available (residual) chlorine shall be maintained which is sufficient to attain the Fecal Coliform limits specified above. Chlorine concentrations in excess of that necessary to reliably achieve these limits shall be avoided.

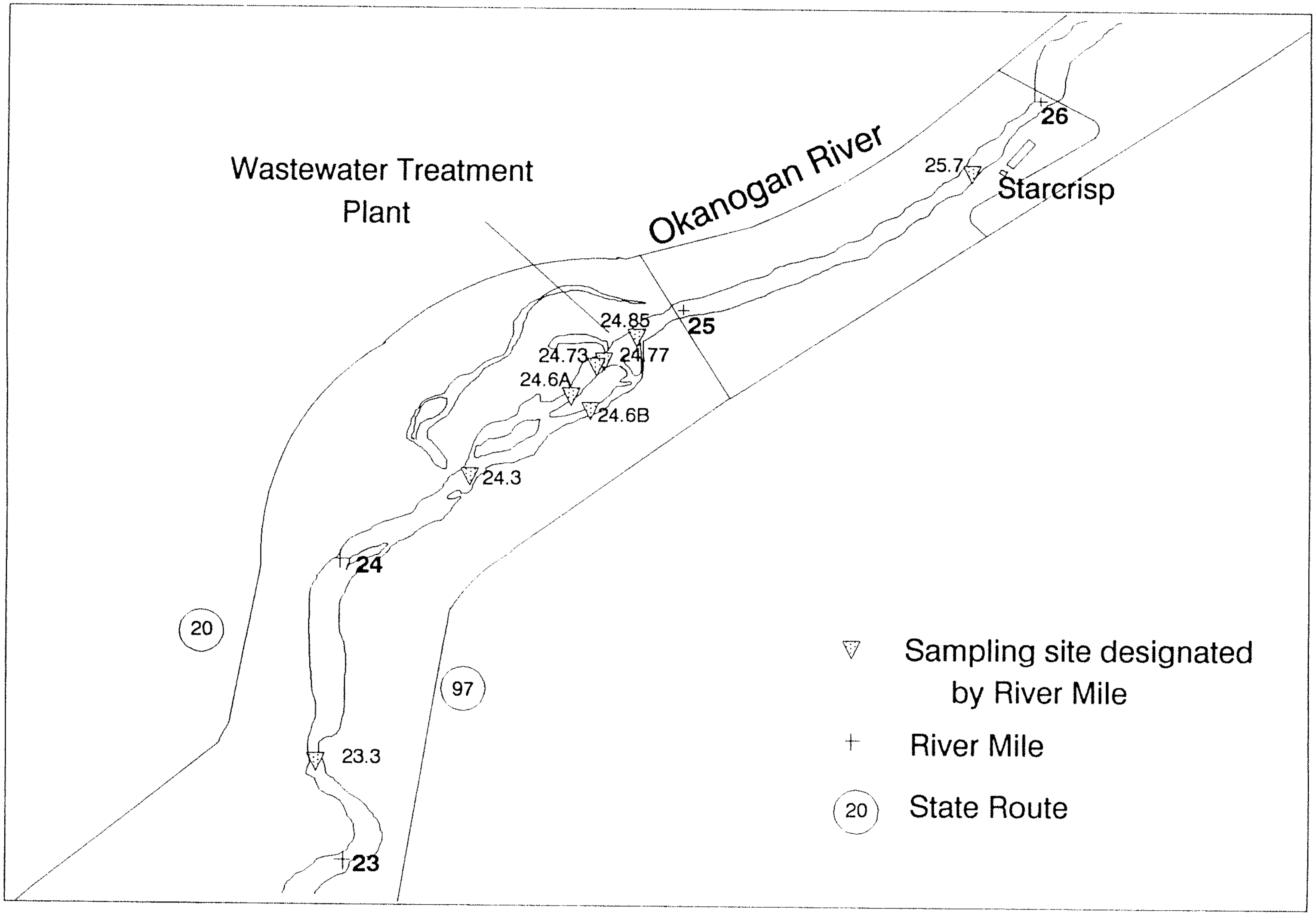

Figure 1. Survey area showing sampling sites as river miles.

METHODS

Three transects were sampled for temperature, pH, and specific conductance as indicators of plume mixing. Transects were located 300 feet upstream of the WTP discharge (RM 24.85) as well as 100 feet and 300 feet downstream (RM 24.77 and 24.73) (Figure 1). Each transect consisted of three surface sampling sites: near the right and left bank, and near the middle of the channel. A Hydrolab Surveyor II was used for field temperature, pH, and specific conductance measurements. Samples for specific conductance were also submitted to the Ecology/EPA Laboratory in Manchester, Washington.

Surface grab samples were collected at ten sites: one upstream of the discharge and nine downstream, on October 18-19, 1988. Most sites were sampled once each day for BOD, COD, dissolved oxygen, solids and nutrients (ammonia, nitrate+nitrite, Kjeldahl-nitrogen, total phosphorus, and soluble reactive phosphorus), chloride, temperature, pH, and specific conductance. In addition, fecal coliform bacteria samples were collected on October 19 at four downstream sites. Total residual chlorine was analyzed in the field using a La Mott Palin DPD test kit (detection limit: 0.1 mg/L).

Grab samples were also collected from the Starcrisp discharge on October 17. Streamflow, BOD, COD, ammonia, nitrate+nitrite, total phosphorus, chloride, specific conductance, total suspended solids, temperature, pH, and dissolved oxygen were sampled from the waste stream. Total residual chlorine was sampled on October 18.

Samples were held on ice and delivered to the Ecology/EPA Laboratory in Manchester where all analyses except Kjeldahl-nitrogen were conducted. Samples were analyzed according to EPA (1983) and APHA *et al.* (1985). Kjeldahl-nitrogen was analyzed by a contract laboratory. Dissolved oxygen was measured by Winkler titration. Table 2 contains a summary of the field and laboratory parameters measured.

The Okanogan River flow was measured upstream of the discharge at the bridge near RM 26 (Figure 1) on October 19, 1989, using a Gurley flow meter. This measurement was compared with that provided by the USGS for the Malott gaging station (RM 17, Station No. 12447200).

Field work was conducted by Barbara Carey and Greg Pelletier of Environmental Investigations and Laboratory Services Program with assistance from Harold Porath of the Central Regional Office.

Time-of-travel for the stretch of river below the discharge (RM 24.73) to the last boat-accessible site (RM 23.3) was estimated by following several apples released 300 feet below the discharge.

RESULTS AND DISCUSSION

No appreciable difference was found between upgradient and downgradient water quality when sample results were compared (Table 3). Fecal coliform bacteria (FC) exceeded the water quality standard (Chapter 173-201 WAC) both above and below the discharge following a 0.2-inch rain event on October 18. Although the source(s) of the elevated FCs could not be identified, the two effluent FC samples collected on October 19 suggest that FC loading in excess of permit limits may have contributed to high river loading (Table 4).

Table 2. Sampling schedule for the Okanogan River receiving water study, October 18 - 19, 1988.

River Mile	Station Name*	Date	Time	Depth	Dis-chg.	Temp.	pH	Conduc. (F)	Conduc. (L)	D.O.	TRC	BOD-5	COD	NH_3	NO_3 + NO_2	Kjel-dahl-N	SRP	Tot. P	Chl	TS	TNVS	TSS	NVSS	FC
25.70	Starcrisp	10/17	1615	0.2	X	X	X		X	X		X	X	X	X			X	X			X		
25.70	Starcrisp	10/18	1630	0.2							X													
24.85	Upstream-RB	10/18	0938	0.2		X	X	X																
24.85	Upstream-MID (surface)	10/18	0925	0.2		X	X	X	X			X	X	X	X	X	X	X	X			X		
24.85	Upstream-MID (surface)	10/18	1045	0.2		X	X	X		X														
24.85	Upstream-MID (surface)	10/19	0845	0.2		X	X	X	X	X			X	X	X			X	X			X		X
24.85	Upstream-MID(bottom)	10/18	0927	2.0		X	X	X																
24.80	30'below outfall	10/18	1013	0.2		X	X	X																
24.80	30'below outfall	10/19	0850	0.2				X			X													
24.77	Down-100 ft- RB	10/18	1005	0.2		X	X	X																
24.77	Down 100 ft- MID (surf)	10/18	0953	0.2		X	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	
24.77	Down 100 ft- MID (surf)	10/19	0900	0.2		X	X	X	X				X	X	X	X		X	X			X		X
24.77	Down 100 ft- MID (mid)	10/18	0955	1.0		X	X	X																
24.77	Down 100 ft-Mid(bottom)	10/18	0957	2.0		X	X	X																
24.77	Down 100 ft- LB	10/18	1010	0.2		X	X	X																
24.77	Down 100 ft- LB	10/19	0910	0.2		X	X	X																
24.73	Down 300 ft- RB	10/18	1100	0.2		X	X	X		X														
24.73	Down 300 ft- MID	10/18	1115	0.2		X	X	X	X			X	X	X	X	X	X	X	X			X		
24.73	Down 300 ft- MID	10/19	0908	0.2		X	X	X	X				X	X	X	X		X	X			X		X
24.73	Down 300 ft- LB	10/18	1125	0.2		X	X	X																
24.6A	Down-3	10/18	1155	0.2		X	X	X	X				X	X	X	X	X	X	X			X		
24.6A	Down-3	10/19	0925	0.2		X	X	X	X				X	X	X			X	X			X		X
24.6B1	Down-4	10/18	1215	0.2		X	X	X	X				X	X	X	X		X	X			X		
24.6B2	Down-5	10/18	1215	0.2		X	X	X	X				X	X	X	X	X	X	X			X		
24.30	Down-6	10/18	1245	0.2		X	X	X	X	X		X	X	X	X	X	X	X	X			X		
24.30	Down-6	10/19	0947	0.2		X	X	X	X	X			X	X	X			X	X			X		
23.30	Down-7	10/18	1325	0.2		X	X	X	X			X	X	X	X	X	X	X	X			X		
23.30	Down-7	10/19	1028	0.2		X	X	X	X				X	X	X			X	X			X		
17.00	Down-8	10/18	1540	0.2		X	X	X	X	X		X	X	X	X	X	X	X	X			X		
17.00	Down-8	10/19	1300	0.2		X	X	X	X	X			X	X	X			X	X			X		X
Filter-Blank		10/18															X							
De-Ionized Water		10/18												X	X		X	X						

* RB = Right Bank; MID = mid-channel; LB = Left Bank

Table 3. Okanogan River receiving water results for October 18-19, 1988.

River Mile	Station Name	Date	Time	Depth (m)	Discharge (cfs)	Temp C	pH	Specific Conductance (Field) (umhos/cm)	Specific Conductance (Lab) (umhos/cm)	Dissolved O2- Winkler (mg/L)	Dissolved O2- Hydrolab (mg/L)	Dissolved O2--% sat (mg/L)	Total Residual Chlorine (mg/L)	BOD-5 (mg/L)	COD (mg/L)
25.70	Starcrisp	10/17/88	16:15	0.20	0.20	18.8	8.0		640	8.5				19	78
25.70	Starcrisp	10/18/88	16:30	0.20									<0.1		
24.85	Upstream-RB	10/18/88	09:38	0.20		11.20	8.10	270							
24.85	Upstream-MID (surface)	10/18/88	09:25	0.20		11.20	8.10	302	327		11.10			<3	9
24.85	Upstream-MID (surface)	10/18/88	10:45	0.20		11.0	8.1	303		10.8	11.30				
24.85	Upstream-MID (surface)	10/19/88	08:45	0.20		10.30	8.0	298	304	10.30	11.30				10
24.85	Upstream-MID(bottom)	10/18/88	09:27	2.0		11.2	8.1	302							
24.80	Boil (30'below outfall)	10/18/88	10:13	0.20		11.10	8.1	300							
24.80	Boil (30'below outfall)	10/19/88	08:50	0.20				300					<0.1		
24.77	Down-100 ft- RB	10/18/88	10:05	0.20		11.1	8.0	305							
24.77	Down 100 ft- MID (surf)	10/18/88	09:53	0.20		11.1	8.0	305	309		11.20			<3	13
24.77	Down 100 ft- MID (surf)	10/19/88	09:00	0.20		10.40	8.0	297	307		11.30				10
24.77	Down 100 ft- MID (mid)	10/18/88	09:55	1.0		11.10	8.0	305			11.20				
24.77	Down 100 ft-Mid(bottom)	10/18/88	09:57	2.0		11.2	8.0	305							
24.77	Down 100 ft- LB	10/18/88	10:10	0.20		11.1	8.1	303			11.20				
24.77	Down 100 ft- LB	10/19/88	09:10	0.20		10.40	8.0	297			11.30				
24.73	Down 300 ft-RB	10/18/88	11:00	0.20		11.0	8.1	303		10.60	11.30				
24.73	Down 300 ft- MID	10/18/88	11:15	0.20		11.0	8.1	300	300		11.20			<3	8
24.73	Down 300 ft- MID	10/19/88	09:08	0.20		10.40	8.0	299	308		11.30				10
24.73	Down 300 ft- LB	10/18/88	11:25	0.20		11.0	8.1	300			11.30				
24.6A	Down-3	10/18/88	11:55	0.20		11.0	8.1	302	308		11.50				12
24.6A	Down-3	10/19/88	09:25	0.20		10.40	8.0	298	307		11.40				8
24.6B1	Down-4	10/18/88	12:15	0.20		10.2	8.1	312	328		10.70				12
24.6B2	Down-5	10/18/88	12:15	0.20		10.2	8.1	312	326		10.70				11
24.30	Down-6	10/18/88	12:45	0.20		10.90	8.10	301	314	10.90	11.70			<3	8
24.30	Down-6	10/19/88	09:47	0.20		10.3	8.0	293	320	10.40	11.40				9
23.30	Down-7	10/18/88	13:25	0.20		10.80	8.10	296	314		11.60			<4	11
23.30	Down-7	10/19/88	10:28	0.20		10.3	8.0	296	312		11.40				7
17.00	Down-8	10/18/88	15:40	0.20		10.70	8.10	309	320	11.20	11.90			<3	10
17.00	Down-8	10/19/88	13:00	0.20		10.4	8.0	302	325	10.80	11.50				8
Filter-blank		10/18/88													
De-Ionized Water		10/18/88													

Table 3. (Continued)

River Mile	Station Name	Date	Time	Depth (m)	Ammonia (mg/L-N)	Nitrate+ Nitrite (mg/L-N)	Kjeldahl-N (mg/L-N)	Soluble Reactive P (mg/L)	Total P (mg/L)	Chloride (mg/L)	Total Solids (mg/L)	Total NV Solids (mg/L)	TSS (mg/L)	NVSS (mg/L)	Fecal Coliform (#/100 mL)
25.70	Starcrisp	10/17/88	16:15	0.20	0.27	1.40			0.11	7.0			7		
25.70	Starcrisp	10/18/88	16:30	0.20											
24.85	Upstream-RB	10/18/88	09:38	0.20											
24.85	Upstream-MID (surface)	10/18/88	09:25	0.20	<0.01	0.02	0.16	0.01	0.04	2.9			2		
24.85	Upstream-MID (surface)	10/18/88	10:45	0.20											
24.85	Upstream-MID (surface)	10/19/88	08:45	0.20	<0.01	0.01			0.03	2.70			7		210
24.85	Upstream-MID(bottom)	10/18/88	09:27	2.0											
24.80	Boil (30'below outfall)	10/18/88	10:13	0.20											
24.80	Boil (30'below outfall)	10/19/88	08:50	0.20											
24.77	Down-100 ft- RB	10/18/88	10:05	0.20											
24.77	Down 100 ft- MID (surf)	10/18/88	09:53	0.20	0.01	0.04	0.20	0.02	0.05	3.2	240	110	3	2	
24.77	Down 100 ft- MID (surf)	10/19/88	09:00	0.20	<.01	0.02	0.14		0.04	2.90			10		360
24.77	Down 100 ft- MID (mid)	10/18/88	09:55	1.0											
24.77	Down 100 ft-Mid(bottom)	10/18/88	09:57	2.0											
24.77	Down 100 ft- LB	10/18/88	10:10	0.20											
24.77	Down 100 ft- LB	10/19/88	09:10	0.20											
24.73	Down 300 ft-RB	10/18/88	11:00	0.20											
24.73	Down 300 ft- MID	10/18/88	11:15	0.20	<.01	0.01	0.18	0.01	0.04	3.10			1		
24.73	Down 300 ft- MID	10/19/88	09:08	0.20	<.01	0.02	0.26		0.04	2.80			7		270
24.73	Down 300 ft- LB	10/18/88	11:25	0.20											
24.6A	Down-3	10/18/88	11:55	0.20	<.01	0.02	0.14	0.01	0.04	6.20			1		
24.6A	Down-3	10/19/88	09:25	0.20	<.01	0.01			0.03	2.80			9		260
24.6B1	Down-4	10/18/88	12:15	0.20	<.01	0.02	0.15		0.05	2.80			1		
24.6B2	Down-5	10/18/88	12:15	0.20	<.01	0.02	0.15	0.01	0.04	3			1		
24.30	Down-6	10/18/88	12:45	0.20	<.01	0.02	0.14	0.01	0.03	3			1		
24.30	Down-6	10/19/88	09:47	0.20	<.01	0.02			0.06	2.70			8		
23.30	Down-7	10/18/88	13:25	0.20	<.01	0.02	0.28	0.01	0.03	3.10			1		
23.30	Down-7	10/19/88	10:28	0.20	<.01	0.01			0.02	2.80			5		
17.00	Down-8	10/18/88	15:40	0.20	<.01	0.01	0.05	0.01	0.03	3.10			1		
17.00	Down-8	10/19/88	13:00	0.20	<.01	0.01			0.02	2.80			5		410
Filter-blank		10/18/88						<0.01							
De-Ionized Water		10/18/88			<0.01	<0.01		<0.01	0.02						

Table 4. Effluent data for the Okanogan WTP during the October 1988 receiving water survey (From Reif, 1990).

	Composite	Effluent Grab		Effluent Grab	
Date	10/18-19	10/18		10/19	
Time	24 hours	1123	1523	0934	1240
Discharge (cfs)	0.63				
Temperature (°C)		18.4	18.2	17.2	
pH (S.U.)					
(Field)	7.8	7.7	7.5	7.6	
(Lab)	7.7	7.3	7.4	7.5	
Spec. Cond. (umhos/cm)					
(Field)	1,285	1,280	1,445	1,220	
(Lab)	1,490	1,420	1,590	1,340	
T. Resid. Chl. (mg/L)			0.80	0.10	0.10
Ammonia-N (mg/L)	8.80	6.80	9.80	7.10	
Un-ionized Ammonia (mg/L)	0.21	0.17	0.24	0.17	
Nitrate+Nitrite-N (mg/L)	8.20	8.80	8.10	10	
Chloride (mg/L)	160				
Fecal coliform (#/100 mL)				2,100*	480*

*Permit limits are 200/100 mL monthly average; 400/100 mL weekly average.

Mixing

The estimated mixing ratios during the survey, 834:1 on October 18 and 1,700:1 on October 19, are two and four times the 7-day, 10-year low flow (7Q10) ratio for the Malott flow record, respectively (Table 5).

Dilution zone guidelines recommend that mixing ratios exceed 20:1 using 15% of the available receiving water flow. The dilution ratio using 15% of the 7Q10 flow (336 cfs) and full plant capacity (0.84 cfs) is 61:1, three times the recommended minimum.

Despite fairly high loading to the plant (75% of capacity) and low river flow (125-150% of 7Q10), conductivity transects indicated rapid, thorough mixing of the effluent plume. Likewise, individual conductivity measurements throughout the water column at a point estimated to be about 30 feet below the diffuser were similar to upstream and downstream measurements (Table 3).

Rapid mixing was indicated using chloride as an effluent tracer. Measurements 100 feet downstream on October 18, indicate 0.16% effluent; 300 feet downstream 0.10% effluent using the mass balance formula:

$$\frac{C_{measured} - C_{background}}{C_{effluent} - C_{background}} \times 100$$

where $C_{measured}$ = Chloride at a downstream river site (mg/L)
$C_{background}$ = Chloride upstream of the discharge (mg/L)
$C_{effluent}$ = Chloride in effluent (24-hour composite sample, 160 mg/L) (Reif, 1990)

These values translate to a mixing ratio of 625:1 at 100 feet and 1,000:1 at 300 feet. Mixing appears to be thorough and rapid, since the estimated mixing ratio using average daily flow for the river and WTP on October 18, (834:1), is between those calculated at 300 and 1,000 feet using chloride as a tracer.

Comparison with Historical Data

Despite a four-fold higher dilution ratio during the October 1977 survey than during the 1988 survey, TRC and specific conductance were much lower during the 1988 survey within 30 to 100 feet of the outfall (Table 6). Temperature, conductivity, and TRC, all of which were significantly affected 50 feet from the discharge in 1977, were not different from background conditions 30 to 100 feet downstream of the diffuser in 1988. Un-ionized ammonia which exceeded both chronic and acute toxicity criteria at 50 feet in 1977 was not sampled closer than 100 feet from the diffuser in 1988. However, at 100 feet, un-ionized ammonia was far below toxicity criteria in 1988.

Total Maximum Daily Load Analysis

Neither acute nor chronic toxicity criteria were exceeded for either ammonia or TRC 100 feet below the discharge during the survey. However, each were of concern for a Total Maximum Daily Load (TMDL) analysis near the Okanogan WTP discharge.

Table 5. Dilution ratio estimates for the Okanogan discharge.

	Flow (cfs)		
Location	10/18	10.19	(Malott Flow) 7Q10
Okanogan River @ Okanogan (Rm 26)	525	---	---
Okanogan River @ Malott (USGS gage 12447200; Rm 17.0)	526	1,070	336
Okanogan WTP	(0.41 MGD)* 0.63*	(0.41 MGD)* 0.63*	(0.54 MGD)** 0.84**
TOTAL	525.6+	1,070.6	336.8
Dilution Ratio [(upstream flow + WTP flow)/WTP flow]	834:1	1,698:1	400:1

* 24-hour average for 10/18 - 19/88.

** Okanogan WTP permitted flow

\+ Flow at Okanogan used, since Malott and Okanogan flows were so similar.

Table 6. Comparison of receiving water data collected in October 1977 with that collected during October 1988 survey.

River Mile Station Name	24.85 Upstream Mid-channel (surface)	Upstream	24.80 30 ft below diffuser	50 ft below outfall	24.77 100 ft below diffuser	100 ft below outfall	24.73 300 ft below diffuser	300 ft below outfall	Effluent composite (24 hr)	Effluent composite (24 hr
Date	10/18-19/88*	10/11-12/77*	10/18-19/88	10/11-12/77*	10/18-19/88	10/11-12/77*	10/18-19/88	10/11-12/77*	10/18-19/88	10/10-13/77
Temperature C	10.80 +/-0.5, n=3	11.10	11.10 n=1	17.20	10.8 +/-0.5, n=2	11.10	10.8 +/-0.4, n=3	11.10		
pH	8.10 +/-0.1, n=3	7.0	8.1 n=1	7.20	8.0 n=2	7.0	8.10 +/-0.1, n=3	7.0	7.80	7.20
Specific Conductance(umhos/cm) (umhos/cm) Field	301 +/-3, n=3	325	300 n=2	1,283	301 +/-6, n=2	342	301 +/-2, n=3	---		
Specific Conductance (umhos/cm) Lab	316 +/-16, n=2				308 +/-1, n=2		304 +/-6, n=2	---	1,285	1,283
Dissolved Oxygen (mg/L)-Winkler	10.60 +/-0.4, n=2	11.80		5.10		11.80	10.60 n=1	11.80		
Dissolved Oxygen (% sat)	97.80 +/-4.3, n=2	110		54.60		110	99 n=1	110		
Total Residual Chlorine (mg/L)		0	<.01 n=1	5.30		0.20		0	0.3, n=3	5.30
Ammonia-N (mg/L)	<0.01 n=2	<0.02		14.90	0.01 n=2	0.14	<0.01 n=2	0.03	8.80	14.90
Unionized Ammonia (mg/L)				0.06		0.00		0.00	0.214**	0.048***
Nitrate+Nitrite-N (mg/L)	0.02 +/-0.007, n=2	<0.02		1.2	0.03 +/-0.01, n=2	<0.12	0.02 +/-0.007, n=2	<0.02	8.20	1.17
Total Inorganic N (mg/L)		---		16.1						
Kjeldahl-N (mg/L)	0.16 n=1	0.41		28.50	0.17 +/-0.04, n=2	0.46	0.22 +/-0.06, n=2	0.31		
Organic Nitrogen (mg/L)		---		13.60		0.32		0.28		
Total Nitrogen (mg/L)		---		29.7						
Soluble Reactive P (mg/L)	0.01 n=1	<0.02		<0.02	0.02 n=1	0.10	0.01 n=1	<0.02		
Total P (mg/L)	0.04 +/-0.007, n=2	<0.02		<0.02	0.05 +/-0.007, n=2	0.16	0.04 n=2	0.03	6.70	8.60

* 1988 sample results are a mean of the number N; 1977 values represent single samples.
** Assuming temperature of 10.8 degrees C, pH=8.1.
*** Assuming temperature of 11.0 degrees C, pH=7.2.

Un-ionized Ammonia

Although relatively far-field un-ionized ammonia measurements in the receiving water (100 feet and greater below the discharge) were below toxicity criteria during the survey, effluent un-ionized ammonia exceeded both acute and chronic criteria (Table 7). However, no appreciable toxicity was indicated in the bioassays (Reif, 1989). Both criteria must be met at the end of the discharge pipe unless a dilution zone is designated in the NPDES permit (Ecology, 1988: Chapter 173-201 WAC). Acute toxicity criteria must be met within the dilution zone--as close to the discharge as possible (Ecology, 1989; EPA, 1985). Ten percent or less of the dilution zone length is recommended as a distance for acute toxicity compliance (i.e., 30 feet if the dilution zone is 300 feet long). Chronic criteria must be met at the boundary of the dilution zone.

Therefore, mixing conditions within the typical 300-foot dilution zone were investigated using a mathematical formula for predicting spread of a plume from a point source. Dilution at 20, 30, and 300 feet below the side bank discharge were calculated using Equation 5.9 in Fisher *et al.* (1979). The following data were used to simulate conditions during the survey as well as for 7Q10 design flow conditions.

	10/18/89	7Q10
WTP flow (cfs)	0.63	0.84
Stream depth (feet)	4.0	3.45
Stream velocity (feet/sec)	0.6*	0.52
Stream slope (feet/feet)	0.0054	0.0054
Channel width (feet)	219	189

*Minimum of 12 velocity measurements taken at the Okanogan Bridge. Streamflow conditions for 7Q10 were estimated by multiplying stream depth, velocity, and width by the cube root of the ratio of the 7Q10 river flow to the flow on 10/18/89; i.e., (336/525)1/3.

Dilution predicted by the Fisher (1979) equation is shown below:

Distance downstream (feet)	20	30	300
Dilution on 10/18/89	55:1	68:1	214:1
Dilution at 7Q10	21:1	30:1	115:1

Based on 7Q10 predicted dilution, un-ionized ammonia concentrations at all three downstream sites are below both chronic and acute criteria (Table 7). A pass-through zone for acute toxicity of 20 feet from the discharge therefore appears to protect aquatic life.

Total Residual Chlorine

Current permit conditions for total residual chlorine (TRC) require that concentrations in excess of that necessary to attain fecal coliform limits (200 FC/100 mL monthly average; 400 FC/100 mL weekly average) shall be avoided. Since chlorine is also toxic to aquatic life at low concentrations, a more specific limit for TRC based on the design flow and toxicity criteria is recommended. Unlike other toxic chemicals, however, TRC is intentionally added to the effluent for required disinfection. Ecology is currently developing a policy on TRC regulation that takes this into account.

A TRC concentration to prevent toxicity in the receiving water can be calculated as follows (Ecology, 1989):

Table 7. Comparison of effluent un-ionized ammonia concentrations with model-predictions at three locations under 7Q10 conditions: 20, 30, and 300 feet below the discharge and toxicity criteria.

20 feet below discharge

Effluent Sample	Date	Time	Effluent Un-ionized Ammonia (mg/L)	Un-ionized Ammonia after 30:1 dilution (mg/L)	Toxicity Criteria* Chronic (mg/L)	Toxicity Criteria* Acute (mg/L)
Composite	10/18-19	24 hr	0.190	0.006	0.02	0.12
Grab	10/18	1123	0.147	0.005	0.02	0.12
Grab	10/18	1523	0.212	0.007	0.02	0.12
Grab	10/19	0934	0.154	0.005	0.02	0.12

30 feet below discharge

Effluent Sample	Date	Time	Effluent Un-ionized Ammonia (mg/L)	Un-ionized Ammonia after 36:1 dilution (mg/L)	Toxicity Criteria* Chronic (mg/L)	Toxicity Criteria* Acute (mg/L)
Composite	10/18-19	24 hr	0.190	0.005	0.02	0.12
Grab	10/18	1123	0.147	0.004	0.02	0.12
Grab	10/18	1523	0.212	0.006	0.02	0.12
Grab	10/19	0934	0.154	0.004	0.02	0.12

300 feet below discharge

Effluent Sample	Date	Time	Effluent Un-ionized Ammonia (mg/L)	Un-ionized Ammonia after 115:1 dilution (mg/L)	Toxicity Criteria* Chronic (mg/L)	Toxicity Criteria* Acute (mg/L)
Composite	10/18-19	24 hr	0.190	0.002	0.02	0.12
Grab	10/18	1123	0.147	0.001	0.02	0.12
Grab	10/18	1523	0.212	0.002	0.02	0.12
Grab	10/19	0934	0.154	0.001	0.02	0.12

*Criteria are based on the estimated mixed temperature of 12.2°C and pH of 8.0 using a mass balance of effluent and receiving water.

(TRC chronic toxicity criterion) x (7Q10 dilution factor) x (15% of 7Q10 flow available for dilution) = Daily maximum TRC concentration

or

(0.011 mg/L) x (400) x (0.15) = Daily maximum TRC concentration

= 0.7 mg/L

A TRC maximum permit level of 0.7 mg/L should be implementable with little procedural modifications as the Discharge Monitoring Records show exceedence of this value on only 10 days during all of 1988. A flow proportional chlorinator is recommended to further ensure appropriate concentrations for low WTP flow periods.

Starcrisp Discharge

A consistently flowing discharge into the river near the Starcrisp plant (RM 25.70, Figure 1) on October 18 and 19 did not appear to be the weekly float tank discharge but rather the unregulated, non-contact cooling water. TRC was below detection in the waste stream, while BOD, COD and specific conductance were high for either float tank or non-contact cooling water (Table 3). The flow on October 18 was 0.2 cfs. A strong apple odor was also observed. The periodic float tank discharge has reportedly been removed from the river since the survey (Porath, 1989).

CONCLUSIONS

- The only indication of water quality degradation due to the WTP discharge was fecal coliform bacteria.
- Mixing appeared to be rapid and thorough at sites estimated to be 30 and 100 feet below the outfall, although the outfall location was not confirmed.
- Minimum dilution using 15% of the 7Q10 river flow and full WTP capacity exceeds the minimum 20:1 ratio by a factor of three.
- Water quality downstream of the discharge was much improved compared to conditions before the WTP upgrade in terms of TRC, un-ionized ammonia, specific conductance and temperature.
- Mixing model results using worst case conditions (low river flow and high effluent discharge) indicate that chronic toxicity criteria for un-ionized ammonia would be met 300 feet below the discharge.
- Assuming that effluent and receiving water conditions used in the mixing models are conservative for the critical low flow period, un-ionized ammonia acute toxicity is unlikely 30 feet beyond the discharge pipe. EPA (1985) and Ecology (1989) suggest that a pass-through zone of 10% or less of the mixing zone length may be allowed for acute toxicity. Therefore, if a dilution zone of 300 feet were established, a pass-through zone of 30 feet would be allowable.
- The Starcrisp non-contact cooling water discharge was flowing on both October 18 and 19 (0.2 cfs). High BOD, COD, and specific conductance make it an inappropriate unregulated wastewater discharge.

RECOMMENDATIONS

- Specify a dilution zone in the WTP permit such that chronic toxicity criteria are met at the boundary (i.e., not more than 300 feet below the discharge).

- Establish a small pass-through zone inside the dilution zone within which un-ionized ammonia acute toxicity criteria can be exceeded; i.e., not more than 30 feet from the discharge pipe.

- Begin monitoring effluent ammonia to determine if toxicity criteria are being met using dilution ratios for worst case conditions: 7.2:1 at 30 feet and 22:1 at 300 feet. At least monthly effluent composite samples should be collected for ammonia and pH (temperature already measured once daily) with appropriate QA/QC procedures. If violations of dilution zone or pass-through zone requirements exceed the allowable once in three years frequency, then the permit should be amended to prevent further violations.

- Establish a permit limit for TRC of 0.7 mg/L for the WTP. The effluent chlorinator should operate flow proportionally to avoid excessive disinfection during low flow periods.

- Remove Starcrisp's cooling water discharge from the river. Verify that the periodic float tank discharge is channeled to the WTP rather than the river.

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